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DESCRIPTION

PHASE SHIFTER ARRANGEMENT AND ANTENNA ARRAY HAVING SUCH A PHASE SHIFTER ARRANGEMENT

TECHNICAL FIELD

The present invention relates to the field of radiofrequency engineering. It relates to a phase shifter arrangement according to the preamble of claim 1 and an antenna array having such a phase shifter arrangement according to the preamble of claim 17.

Such a phase shifter arrangement or such an antenna array is disclosed, for example, in the document US-B1-6,310,585.

PRIOR ART

In mobile radio technology, antenna arrays or antennas, in which two or more individual radiators are arranged one behind the other in a mounting direction and are driven via a common supply network, have long been known for equipping the base stations. In order to be able to take better account of the different conditions at the location of the respective base station and of the interaction with other base stations, it has proved to be advantageous to provide the antennas with the possibility of a "down tilt". This may take place, in principle, by purely mechanical means by the antenna being designed such that it can be adjusted at the point at which it is fixed to the mast. One disadvantage of this is the fact that considerable complexity is required to adjust and alter such a mechanical down tilt and it is usually necessary to climb the mast for this purpose.

Several suggestions have therefore been made to carry out an "electrical down tilt" by, in the case of a fixed antenna, the individual radiators of the antenna or the antenna array being driven on different phases such that the radiation lobe formed by superimposing the phase-shifted arrays of individual radiators is tilted in a desired manner ("phased array"). Examples of such an electrical "down tilt" are disclosed in US-A-6,198,458 or in US-A-5,801,600 or in US-A-5,905,462. Used here are special differential phase shifters (see also DE-A1-199 11 905 or US-A-5,949,303) or other phase shifters which are arranged in the supply network of the antenna between the individual radiators and can be adjusted at the same time, for example, via a linkage by means of a motor drive (see also US-A-5,798,675). The simple, electrically controllable adjustability in this case also provides the possibility of remote adjustment from a control center or the like ("remote tilt control").

Combinations of mechanical and electrical down tilts are likewise conceivable (US-A-5,440,318).

In more recent mobile radio transmission methods having a high data transmission rate, as are known, for example, by the abbreviation UMTS, the transition is increasingly being made to using "dual polarized antennas" in order to be able to make use of the effect of "polarization diversity" in which multiple transmission of data is possible on radio waves having a different polarization for the purpose of increasing transmission reliability. The radiators in these antennas in this case each have two radiator elements for the two polarizations and are in the form of, for example, cruciform dipoles or correspondingly designed patch radiators.

The document US-A-6,310,585 mentioned initially has also already proposed an electrically controlled down tilt by means of phase shifters for the dual polarized antennas or antenna arrays. For this purpose, each of the two radiator elements of a radiator within the supply network has in each case one associated phase shifter (40 in fig. 1; 440 in fig. 3), in which, for example, a microstrip line is overlapped to a greater or lesser extent by a displaceable dielectric (column 3, lines 61-65; column 5, lines 1-18). Details on the phase shifters and the associated microstrip lines are not given in the document.

In US-A-6,310,585, the phase shifters for all of the radiator elements of one polarization direction are rigidly coupled mechanically to one another by means of a first rod. The phase shifters for all of the radiator elements of the other polarization direction are likewise rigidly coupled to one another mechanically by means of a second rod. The two rods, for their part, are rigidly connected to one another by means of a central supporting device (415 in fig. 3) and are driven by a pinion via a toothed rack. In addition, two or more flexible positioning elements (420 in fig. 3) are provided which press the dielectric against the microstrip lines below.

Disadvantages of this known phase shifter arrangement are not only the complex displacement mechanism comprising a plurality of individual elements, but also the separate structure of the individual phase shifters which requires high accuracy on assembly and thus increased mounting complexity with, at the same time, increased susceptibility to faults.

SUMMARY OF THE INVENTION

It is therefore the object of the invention to develop a phase shifter arrangement of the type mentioned initially such that the disadvantages of the known phase shifter arrangements are avoided, and such that, in particular, the design is simplified and the desired functionality is reliably achieved, as well as to specify an antenna array having such a phase shifter arrangement.

The object is achieved by all of the features of claims 1 and 17. The core of the invention consists in arranging the microstrip lines of the two phase shifters parallel and next to one another, and in providing a common, displaceable dielectric for the purpose of altering the electrical length of these microstrip lines of the two phase shifters. In this manner, only a single displaceable dielectric is required per radiator, and this may be used to automatically and synchronously adjust the electrical length for the two polarizations. There is thus also only a single row of dielectrics arranged one behind the other provided in the mounting direction of the antenna array, and this row of dielectrics may be displaced at the same time in a particularly simple manner by means of a single rod extending in the longitudinal direction.

In particular, the microstrip lines and the displaceable arrangement of the dielectric are designed such that the electrical length of the two parallel microstrip lines is altered to the same extent when the dielectric is displaced. This ensures that the radiation lobe always has the same orientation for the two polarizations.

In principle, it would also be conceivable to displace

the dielectrics of the phase shifter arrangements transversely with respect to the mounting direction of the antenna array. However, particularly simple is the mechanical system whereby, according to a preferred refinement of the invention, the microstrip lines extend essentially along a longitudinal axis, and the dielectric can be displaced in the direction of the longitudinal axis.

The microstrip lines preferably each have at least one center piece which is completely overlapped by the displaceable dielectric in a first position and is left completely free in a second position. In this case, it is favorable for the setting characteristics if the microstrip lines in the center pieces run transversely with respect to the longitudinal direction and have a meandering structure, since the electrical length is thus altered to a greater extent per unit of the displacement path.

Already disclosed in US-A-3,656,179 is a way of altering the associated characteristic impedance by displacing the dielectric in a bus strip arrangement. In order to reduce the degree of alteration to the characteristic impedance to a tolerable level, another refinement of the invention provides for two or more line sections running parallel in the longitudinal direction to be provided within the meandering structure, and for the microstrip lines to alter their strip width in the line sections running in the longitudinal direction.

The alteration to the strip width is preferably designed such that, when the dielectric is displaced from the second to the first position, the strip width of the overlapped line sections, starting from a minimum strip

width, increases as the overlap increases up to a maximum strip width, in particular the strip width increasing linearly with the displacement path in the longitudinal direction.

Particularly advantageous variation of the characteristic impedance by an average value results when the minimum strip width is selected such that, when there is an overlap with the dielectric in the region of the minimum strip width, the same characteristic impedance of the microstrip lines is produced as in the region of the maximum strip width where there is no overlap with the dielectric. This type of alteration to the strip width is advantageous for each phase shifter which operates with the displacement of a dielectric above a microstrip line, and specifically independently of whether two or more phase shifters have a common dielectric or not.

In addition, adjusting pieces having a differing strip width can be arranged in the line sections running in the longitudinal direction for the purpose of adjusting the characteristic impedance.

The phase shifter arrangement according to the invention is simplified further if the microstrip lines of the two phase shifters are arranged and formed on a common printed circuit board. Together with the common, displaceable dielectric, there is thus a high degree of synchronization with, at the same time, a particularly simple design.

One possible refinement of the printed circuit board consists in the microstrip lines of the two phase shifters being designed to be mirror-symmetrical with respect to a center axis, running parallel to the

longitudinal axis, of the printed circuit board.

In order for the displaceable dielectric to always be in a defined position relative to the microstrip lines below, it is advantageous if the microstrip lines of the two phase shifters and the common dielectric above are pressed flat against one another by means of a spring metal sheet.

A particularly uniform pressing action results when the spring metal sheet is arranged on the underside of the microstrip lines and is electrically insulated from the microstrip lines by means of an intermediate insulating plate, and if the spring metal sheet has a plurality of individual spring tongues distributed over its surface.

Provided for the drive of the phase shifter is preferably a slide which is guided displaceably in the longitudinal direction, can be actuated manually from the outside or using a motor, and is in engagement with the dielectric. This configuration is particularly simple and functionally reliable and has the advantage of retaining its position when the motor drive fails.

It has proven successful in practice to use a plate having a relative dielectric constant of approximately 10, in particular in the form of a glass fiber-reinforced, organoceramic laminate, as the dielectric.

A preferred refinement of the antenna array according to the invention is characterized in that two or more phase shifter arrangements which can be displaced at the same time are arranged one behind the other within the supply network, and in that connections are provided between and downstream of the phase shifter arrangements for the

purpose of connecting the radiators.

Another preferred refinement is distinguished by the fact that radiators are arranged in the antenna array 2n+1 (n=1, 2, 3, ...), that 2n phase shifter arrangements are arranged one behind the other in the associated supply network, that the supply inputs are connected to the supply network between the n-th and the (n+1)-th phase shifter arrangement, and that all of the phase shifter arrangements can be actuated at the same time, the first n phase shifter arrangements operating in opposition to the second n phase shifter arrangements.

Further embodiments are described in the dependent claims.

BRIEF EXPLANATION OF THE FIGURES

The invention will be explained in more detail below with reference to exemplary embodiments in connection with the drawing, in which:

fig. 1 shows a cross section (figure 1A), a plan view from above (fig. 1B) and a longitudinal section (fig. 1C) through an individual phase shifter arrangement comprising two phase shifters according to a preferred exemplary embodiment of the invention;

fig. 2 shows the base plate of the phase shifter arrangement shown in fig. 1;

fig. 3 shows an insulating film of the phase shifter arrangement shown in fig. 1;

fig. 4 shows a plan view (fig. 4A) and a side view (fig. 4B) of the spring metal sheet of the phase shifter arrangement shown in fig. 1;

fig. 5 shows an insulating plate of the phase shifter arrangement shown in fig. 1;

fig. 6 shows the printed circuit board having the two microstrip lines of the phase shifter arrangement shown in fig. 1;

fig. 7 shows the dielectric of the phase shifter arrangement shown in fig. 1;

fig. 8 shows a plan view from above (fig. 8A) and a side view from the front (fig. 8B) of the slide of the phase shifter arrangement shown in fig. 1;

fig. 9 shows the plan view of two sides (figs 9A and B) of a printed circuit board having 8 phase shifter arrangements according to the invention for an antenna array having in total 9 radiators; and

fig. 10 shows the simplified circuit diagram for the antenna array shown in fig. 9.

WAYS OF IMPLEMENTING THE INVENTION

Fig. 10 shows the simplified circuit diagram of an antenna array 105, in which the present invention can advantageously be used. The antenna array comprises in total 9 radiators 106, .., 114, which are arranged one behind the other (one on top of the other) in a

(vertical) mounting direction. Each of the radiators 106, .., 114 comprises two individual radiator elements 106a, b (the reference numerals for the radiator elements in the radiators 107, .., 114 are omitted for clarity). Each of the radiator elements 106a, b is associated with one polarization direction. The two polarization directions are generally at right angles to one another and usually form an angle of 45° with the mounting direction of the antenna array 105. The radiators 106, .., 114 are provided both for emitting and receiving radio waves.

The radiators 106, .., 114 or radiator elements 106a, b are connected, via a supply network 115, to two supply inputs 99a, b, which are arranged within the supply network 115 at the level of the central radiator 110. Each of the two supply inputs 99a, b is assigned one of the polarization directions and is connected to the corresponding radiator elements. In order for the radiators 106, .., 114 to be able to form a "phase array" and to emit and receive an electrically pivotable beam, phase shifters 91a, b, .., 98a, b, are arranged in pairs distributed in the supply network 115. Each pair of phase shifters 91a, b, .., 98a, b forms a phase shifter arrangement. The two phase shifters of a pair of phase shifters or of a phase shifter arrangement are adjusted in synchrony, as is illustrated in fig. 10 by the dashed connecting lines within each pair. All of the phase shifter pairs 91a, b, .., 98a, b are actuated at the same time by a connecting tongue 116 running in the longitudinal direction (mounting direction), which is driven manually or using a motor and is likewise illustrated using dashed lines in fig. 10. The change in the phase shift in the phase shifters 95a, b, .., 98a, b arranged below the supply inputs 99a, b takes place in this case in opposition to the change in the phase shift

in the phase shifters 91a, b, .., 94a, b arranged above the supply inputs 99a, b (i.e. an increase in the phase shift at the bottom corresponds to a decrease in the phase shift at the top, and vice versa), which is indicated in fig. 10 by the arrows in the phase shifters having a different orientation.

The central one of the 9 radiators 106, .., 114, namely the radiator 110, is connected directly to the supply inputs 99a, b and thus operates on a constant phase. The remaining 8 radiators 106, .., 109 and 111, .., 114 each have an associated phase shifter pair. Since the phase shifter pairs 91a, b, .., 98a, b are connected in series within the supply network 115, the individual phase shifts, starting from the center, are summed. If all of the phase shifters are the same, the phase shift toward the outside increases in equal increments: the signal supplied to the supply inputs 99a, b reaches the radiator 109 with a single phase shift, the radiator 108 with a dual phase shift, the radiator 107 with a triple phase shift, and the radiator 106 with a quadruple phase shift. The same applies for the radiators 111 to 114.

A single phase shifter pair or a single phase shifter arrangement now preferably has a construction as is shown in the exemplary embodiment in figs 1 to 8, in which, in fig. 1, different views are depicted of a completely assembled arrangement, whereas figs 2 to 8 show the individual elements of the arrangement shown in fig. 1 in sequence within the arrangement. The printed circuit board 60 shown in fig. 6 and having the microstrip lines 66, 67 in this case only represents the subsection of a longer printed circuit board 90, as is reproduced in fig. 9 for the entire antenna array 105 shown in fig. 10.

The printed circuit board 60 (fig. 6), which is made of, for example, a base material of 0.5 mm in thickness having a double-sided 35 μm Cu coating, has, on the underside, a continuous Cu coating and, on the top side, the conductor tracks shown which are mirror-symmetrical with respect to a center axis 11 and form the microstrip lines 66, 67. The printed circuit board 60 is arranged in the phase shifter arrangement 10 in fig. 1 between a (lower) base plate 20 (fig. 2) and an (upper) slide 80 (fig. 8) such that the conductor tracks of the microstrip lines 66, 67 are on the side of the slide 80. The base plate 20, which may be in the form of, for example, an aluminum plate, has, on the sides, two fastening tabs 21, 22 having corresponding fastening holes 23, 24, by means of which it can be screwed tightly to an antenna housing.

The printed circuit board 60 is fixed in relation to the base plate 20. This is achieved by two lugs 25, 26 which engage in corresponding openings 64, 65 in the printed circuit board 60 (fig. 6) being bent back upward at right angles on the base plate 20. Also provided in the printed circuit board 60 are three guide openings 61, .., 63 in the form of slots which are spaced apart from one another, run parallel to the center axis 11, and in which the slide 80 engages with correspondingly formed and arranged engaging cams 81, .., 83 (fig. 1; fig. 8). The guide openings 61, .., 63 determine the displacement region of the slide 80 relative to the printed circuit board 60.

The slide 80, which may be made of, for example, plastic and may be an injection-molded part, also has two lateral guides 86, 87 which engage over the lateral edge of the printed circuit board 60. On its top side of the slide 80, integrally formed in a depression and one behind the

other in the longitudinal direction, are two driver cams 88, 89 with which an actuating element (not shown) for the slide can engage. Furthermore, two recesses 84, 85 are provided on the slide 80 in order to provide space for the lugs 25, 26 protruding through the printed circuit board 60 from below.

The actual phase shifters 10a, 10b of the phase shifter arrangement 10 are formed by the interaction of the microstrip lines 66, 67 with a dielectric 70 arranged displaceably on the top side of the printed circuit board 60. The dielectric 70 shown in detail in fig. 7 comprises, for example, an organoceramic laminate of the CER-10 type, as can be procured from the US company Taconic, Petersburgh, New York (USA). The glass fiber-reinforced laminate filled with ceramic has a dielectric constant of 10 and very good mechanical properties. A plate of this material is used having a thickness of approximately 0.64 mm. Other dielectrics are also conceivable, however. According to fig. 7, the dielectric 70 has three circular engaging openings 71, .., 73 which are spaced apart from one another and in which the slide 80 engages with its engaging cams 81, .., 83. The dielectric 70 is thus fixed in relation to the slide 80 and is displaced along with the slide 80. Furthermore, two recesses 74, 75 are provided in the dielectric 70 which are comparable in shape and function to the recesses 81, 82 of the slide 80.

The interaction of the microstrip lines 66, 67 and the dielectric 70 takes place essentially in the region of the meandering center pieces 66b, 67b of the microstrip lines 66, 67 which are each arranged between connection pieces 66a, c and 67a, c and run transversely with respect to the center axis 11 (fig. 6). Each of the

center pieces 66b, 67b comprises two or more (in the example in fig. 6, 5) line sections 66d, .., h, which run parallel to the center axis 11 and are connected to one another for the purpose of forming the meandering pattern on alternating sides by means of U- or V-shaped bent pieces. Within the line sections 66d, .., h, the line width varies linearly with respect to the length and in the process decreases from left to right. Since the dielectric 70 with its left-hand edge moves when being displaced precisely in the region of the line sections 66d, .., h, when the dielectric is displaced, regions of the line sections 66d, .., h having different line widths are covered or not covered.

There is a particular reason for the variation in the line width of the line sections 66d, .., h: In order to maintain the (conventional) characteristic impedance of the microstrip lines 66, 67 of 50 ohms, the line width in the case of the materials and dimensions used is approximately 1.5 mm (without a dielectric on top). In the region of the dielectric on top, however, only a line width of approximately 0.98 mm is required for a characteristic impedance of 50 ohms owing to the dielectric. Therefore, if the line width outside the region of coverage of the dielectric is set at 1.5 mm and at 0.98 mm in the region of continuous coverage and a linear transition between these two extreme values is assumed in the intermediate line sections 66d, .., h, the deviation of the actual characteristic impedance when the dielectric 70 is displaced varies by the average value of 50 ohms, the characteristic impedance being more than 50 ohms if the dielectric 70 is shifted to the left far beyond the line sections 66d, .., h, and being less than 50 ohms if the dielectric 70 is shifted only slightly beyond the line sections 66d, .., h. Since only the

absolute value of the difference is relevant for the (undesired) erroneous adjustment, and not the mathematical sign, a larger displacement region of the dielectric and thus a larger phase shift over a larger frequency range can thus be obtained utilizing the maximum permissible erroneous adjustment. In addition, it is possible for the electrical properties to be optimized by adjusting pieces 68, 69 being provided which are wider in the center pieces 66b, 67b (fig. 6).

The two microstrip lines 66, 67 are (as can easily be seen in fig. 6) formed and arranged such that they are mirror-symmetrical with respect to the center axis 11. The dielectric 70 is selected to be so wide that, in the event of a displacement in the direction of the center axis 11, the meandering center pieces 66b, 67b of the microstrip lines 66, 67 are overlapped or left free in the same manner. This makes it possible, without high complexity and with functional reliability to achieve synchronization between the two phase shifters 10a and 10b and to make the phase shifts in the two phase shifters 10a, b largely uniform.

However, an essential element ensuring functional reliability is the fact that the dielectric 70 bears tightly against the surface of the printed circuit board 60 carrying the microstrip lines 66, 67, if possible without an air gap. This is achieved by means of a flat spring metal sheet 40 (figs 4A, B) which is arranged between the base plate 20 and the printed circuit board 60 and presses the printed circuit board 60 from below against the dielectric 70 held in the slide 80. The spring metal sheet 40 has (as does the base plate 20) lateral fastening tabs 41, 42 having corresponding fastening holes 43, 44 which are aligned with the

fastening holes 23, 24 in the base plate 20. Arranged distributed over the surface of the spring metal sheet 40 is, next to one another, a large number of individual spring tongues 45 which have been produced, for example, from the spring metal sheet 40 by a stamping or bending process. The spring metal sheet 40 is electrically insulated from the base plate 20 by means of an intermediate, thin insulating film 30 (fig. 3) which matches the base plate 20 and the spring metal sheet 40 in terms of the lateral fastening tabs 31, 32 and fastening holes 33, 34. The spring metal sheet 40 is furthermore electrically insulated with respect to the lower Cu layer of the printed circuit board 60 by means of an intermediate, for example 0.5 mm thick, insulating plate 50 (fig. 5), against which the spring tongues 45 press. The insulating plate has openings 54, 55, through which the lugs 25, 26 of the base plate 20 pass through for fixing purposes. The slot-like guide openings 51, .., 53 are analogous to the guide openings 61, .., 63 in the printed circuit board 60 in terms of function and shape.

The exemplary embodiment shown in figs 1 to 8 relates only to a phase shifter arrangement comprising two phase shifters 10a, b which is correspondingly only suitable for adjusting a dual polarized radiator. If, as is shown in fig. 10, an antenna array 105 comprises more than two, for example 9, radiators 106, .., 114, and two or more, in the example 8, phase shifter arrangements are required for electrically pivoting the antenna beam, these phase shifter arrangements, together with the supply network 115, are preferably integrated on a single printed circuit board. Such a printed circuit board 90 for in total 9 radiators and 8 phase shifter arrangements is reproduced in fig. 9. Formed on this printed circuit

board 90 are, mirror-symmetrically with respect to the center axis 11, two microstrip lines 90a, b having branches which at the same time form a supply network with the power distributed over two or more antenna connections 102a, b, .., 104a, b (for simplicity only the antenna connections for 4 radiators are provided with reference numerals in fig. 9B; in total there are antenna connections for 9 radiators or 18 radiator elements).

Formed within the supply network of the microstrip lines 90a, b are, in analogy to fig. 6, meandering center pieces 91a, b, .., 98a, b which are each part of a phase shifter arrangement 91, .., 98 comprising two phase shifters. The supply inputs 99a, b are arranged in the center of the printed circuit board 90. Each of the phase shifter arrangements 91, .., 98 is assigned (in analogy to figs 1 to 8) a dielectric which can be displaced by means of a slide, a base plate, and a spring metal sheet which is mounted such that it is insulated. Correspondingly, in each of the phase shifter arrangements 91, .., 98, guide openings 100 and openings 101 are provided for engagement of the base plate. The (nine) slides of all of the phase shifter arrangements 91, .., 98 are in engagement with a common actuating element (not shown) which extends along the center axis 11 over the entire printed circuit board 90 and can be displaced in the longitudinal direction manually from the outside or by means of a controlled motor drive.

<u>In summary the following can be said:</u>
Phase shifters are required to achieve a variable down tilt in the case of an antenna array. It must be possible for the main lobe of the antenna to be lowered beyond the horizontal at least to a first zero position. In mobile radio engineering (GSM, UMTS), it is necessary to fulfill

the following requirements:

In the case of large antennas, it must be possible to alter the down tilt between 0° and approximately 8°; for this purpose, it must be possible for the phase to be altered continuously between 0° and approximately 45° by means of the phase shifter.

In the case of small antennas, it must be possible to alter down tilt between 0° and approximately 16°; for this purpose, it must be possible for the phase to be altered continuously between 0° and approximately 85° by means of the phase shifter.

There are several possible ways of altering the phase. The following relationship applies between the electrical and the mechanical length of a line:

$$I_{elec} = I_{mech}\sqrt{\varepsilon_r}$$

The electrical length is proportional to the phase: $\varphi = \frac{I_{elec}}{\lambda} 360°$

In order to alter the phase, the mechanical length or the ε_r can be altered.

A patent has already been applied for by the applicant for a phase shifter with means for altering the mechanical length of the line.

A phase alteration by altering the ε_r can be achieved in the case of a microstrip line by a dielectric being laid on the line (see DE-A1-199 11 905).

According to the present solution, two or more line sections lying parallel and next to one another are connected to one another by a 180° corner to form a meandering structure. A dielectric having a high ε_r is pushed over this line structure, a common dielectric being used for two adjacent phase shifters. The maximum possible phase shift is given by the number of line sections and their length which at the same time corresponds to the displacement path of the dielectric.

Using 5 parallel line sections, a phase shift of 46° is achieved; with 7 parallel line sections, a phase shift of 65° is achieved. In order to achieve an even greater phase shift, two or more phase shifters can be connected one behind the other.

By using an uneven number of line sections lying parallel and next to one another, the phase shifter can be integrated very effectively in a supply network. However, the phase shifter may also be realized using an even number of lines, which may be more advantageous for other applications.

Each individual line section in the phase shifter has a line width which can be altered linearly (is linearly tapered). In the 0° position of the phase shifter (the dielectric is not over the line sections), the line width is narrower and is of such a width that, together with the dielectric pushed on top of it, the system impedance (50 Ω) is given. At the other end of the line sections, the line width corresponds to the normal microstrip. Despite the tapered line sections, depending on the position of the displaceable dielectric, there is an erroneous adjustment. Erroneous adjustment may be compensated for by small adjusting pieces ("stubs") in

the line structure.

The phase shifter operates as follows: a base plate made of aluminum is screwed onto the antenna housing and positions, by means of two bent-back lugs, the printed circuit board having the line structure. The displaceable dielectric is located on the printed circuit board. Between the aluminum plate and the printed circuit board is a spring metal sheet which presses the printed circuit board against the dielectric. The printed circuit board (ground), the spring metal sheet and the aluminum plate are insulated from one another by additional insulators.

It is possible to use a substrate having a high ε_r as the dielectric. This thin platelet is held by an additional plastic part (slide), which also has driver cams for the slide apparatus. It is also possible, by selecting a suitable plastic or a ceramic, for the dielectric platelet and the plastic part to be integral.

The phase may be set by means of a manually or electrically operated drive.

LIST OF REFERENCE NUMERALS

10	Phase shifter arrangement
10a, b	Phase shifter
11	Center axis
20	Base plate
21, 22	Fastening tab
23, 24	Fastening hole
25, 26	Lugs
30	Insulating film
31, 32	Fastening tab
33, 34	Fastening hole
40	Spring metal sheet
41, 42	Fastening tab
43, 44	Fastening hole
45	Spring tongue
50	Insulating plate
51, .., 53	Guide opening (slot)
54, 55	Opening
60	Printed circuit board
61, .., 63	Guide opening (slot)
64, 65	Opening
66, 67	Microstrip line
66a, 67a	Connection piece
66b, 67b	Center piece (meandering)
66c, 67c	Connection piece
66d, .., h	Line section
68, 69	Adjusting piece
70	Dielectric
71, .., 73	Engaging opening
74, 75	Recess
80	Slide
81, .., 83	Engaging cams
84, 85	Recess
86, 87	Lateral guide

88, 89	Driver cams
90	Printed circuit board
90a, b	Microstrip line
91, .., 98	Phase shifter arrangement
91a, b, .., 98a, b	Phase shifter (center piece)
99a, b	Supply input
100	Guide opening
101	Opening
102a, b, .., 104a, b	Antenna connection
105	Antenna array
106, .., 114	Radiator
106a, b	Radiator element
115	Supply network
115a, b	Branch (supply network)
116	Connecting tongue